## Landscape and hominin habitation history of Flevoland (central Netherlands)

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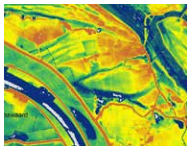



# INTERDISCIPLINARITY BETWEEN HUMANITIES AND SCIENCE

## A FESTSCHRIFT IN HONOUR OF PROF. DR. HENK KARS

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*Contents*

# Landscape and hominin habitation history of Flevoland (central Netherlands)[a]

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## Abstract

In this paper we discuss the landscape development and evidence for hominin activity in Flevoland (central Netherlands). This discussion demonstrates that the area consists of a stacked stratigraphic sequence of different landscapes with (possible) traces of hominin activity dating back to the period 220-170 ka (MIS 7/early MIS 6). In this paper, four time periods are selected for discussion that cover the (1) Upper Middle to Late Saalian (220-170 ka), (2) Younger Dryas (12.9-11.7 ka), (3) mid-Holocene (6000-5400 BP) and (4) Late Holocene (1200-8 BP). During each of these four time periods the study area is characterised by a different environmental setting and specific evidence of hominin activity. Apart from the examination of these four different landscapes and their associated evidence, this paper suggests directions for future research for each of these periods of investigation.

## Introduction

The subsurface of Flevoland contains a stacked sequence of stratigraphic environments that provide evidence of multiple past landscapes. In this paper, four of these landscapes representing different time periods are examined to provide snapshots of past environments (Figure 1), together with the evidence for the nature of discrete hominin activities within these respective landscapes. The four time periods selected for discussion are: (1) late Middle to Late Saalian (220-170 ka; early Middle Palaeolithic), (2) Younger Dryas (12.9-11.7 ka; late Final Palaeolithic), (3) mid-Holocene (6000-5400 BP; Early Neolithic) and (4) Late Holocene (1200-8 BP; Medieval and Modern history). Furthermore, for the oldest period of investigation (late Middle to Late Saalian, 220-170 ka), the study area has been enlarged to include the central Netherlands, in order to better understand, analyse and synthesize the landscape and remains of hominin activities of Flevoland.

The contrasting natural environments and associated geological processes examined for the subsurface of Flevoland are typical of those associated with the Late Quaternary development of the western and central Netherlands.

Although the four different investigated environments are variable and contrasting over time, there are physical similarities between these landscapes. For example, for the most recent period of investigation (1200-8 BP) the peat island Schokland was the focus of research as it was one of the few areas in Flevoland that was inhabited during that period. Peat areas may be part of a coastal landscape, as is the case in the investigated mid-Holocene coastal landscape in Flevoland (see figure 5 in Van den Biggelaar *et al.*, 2015). Although no archaeological remains dating to the mid-Holocene have yet been found in these peat areas this may be due to the lack of research in these areas; for example, investigations in northwest Germany indicated that Neolithic archaeological remains can be present in peat areas within wetland environments (*e.g.*, Swifterbant/Rössen site Hüde 1; Kampffmeyer, 1991). In addition, erosion of the peat area since the mid-Holocene may have destroyed preserved archaeological remains within those areas. At a national or continental scale, coastal and deltaic landscapes are similar in terms of reduced effects of seasonality and the wide variety of available food resources in contrast to most inland areas. The differences in the richness and abundance of natural resources between the inland and coastal areas in the Netherlands affected subsistence practices (*e.g.*, Louwe Kooijmans, 1993; Amkreutz, 2013 for the mid-Holocene). These similarities and differences can be used to better understand hominin-environment interactions at a macroscale. Floodplains and wider valley floors could contain a wide variety of resources in different ecotones. An inland floodplain landscape was present in Flevoland during the Younger Dryas (YD). At that time, Flevoland was part of the terrestrial higher ground in close proximity to the lowland North Sea area, thereby forming an important location to study YD hominin-environment interaction within a northwest European framework. A large diversity of natural sources was also present in Flevoland during the Late Saalian (~ 170 ka) when a deltaic river landscape existed in the area (Busschers *et al.*, 2008). This landscape had a high exploitation potential due to the availability of freshwater resources (*e.g.*, Rhine-Meuse river; see Busschers *et al.,* 2008) and the availability of rocks suitable for the production of artefacts (Van den Biggelaar *et al.*, 2016a).

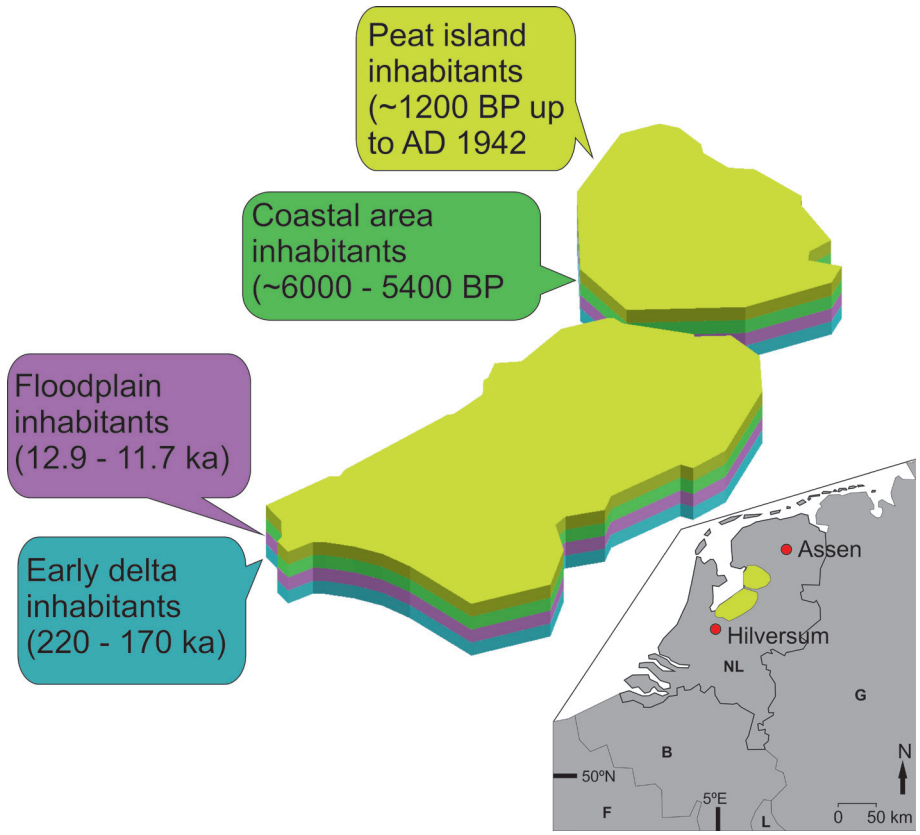


*Figure 1. Map of Flevoland showing each of the four selected periods of investigation as a layer, together with the landscape setting and age of each layer. These layers are in chronological order. The inset shows the location of Flevoland within the Netherlands and the locations of Weichselian archaeological sites at Hilversum and Assen.*

## Late Middle to Late Saalian (220-170 ka, early Middle Palaeolithic)

The western part of the ice-pushed ridges in the central Netherlands contain deposits of the Late Saalian combined Rhine-Meuse fluvial system (~170 ka; Busschers *et al.,* 2008). This fluvial system continued northwards via Flevoland towards the North Sea Basin (Busschers *et al.*, 2008), implying that combined Rhine-Meuse deposits are also present in the buried part of the ice-pushed ridges located in southwest Flevoland. Given the occurrence of early Middle Palaeolithic (EMP) artefacts in the Saalian Rhine-Meuse deposits in the central Netherlands (*e.g.*, Stapert, 1981, 1987, 1991; Van Balen, 2006; Van Balen *et al.*, 2007), combined with the hypothesis that these deposits are possibly also present in the buried part of the ice-pushed ridges of the central Netherlands (southwest Flevoland), EMP artefacts could potentially be present in southwest Flevoland. This hypothesis is supported by the fact that the gravel size and cobble abundance of the pre-glacial Rhine-Meuse deposits in the buried part of these ridges are coarse enough for artefact manufacture (Van den Biggelaar *et al.*, 2016a).

Southwest Flevoland was possibly part of the most northwesternly region with rocks within superficial sediments coarse enough for artefact manufacture during the EMP at the eastern margin of the southern North Sea (i.e. western Netherlands and adjacent offshore area) (Van den Biggelaar *et al.*, 2016a). As the southern North Sea area possibly played a key role in EMP hominin-environment interaction in northwest Europe (Roebroeks, 2014), determining the role of the superficial rock resources in southwest Flevoland in the mobility pattern of EMP hominins in the area is critical to better understanding this relationship (Van den Biggelaar *et al.*, 2016a). This pattern is especially crucial during periods of climatic cooling (*e.g.* early MIS 6) when natural resources were more spatially segregated (Kelly, 1995). To determine the maximum distance between food sources that fitted the mobility pattern of EMP hominins during cool periods, areas lacking EMP remains should be investigated to determine the distance between food patches (Gamble, 1995). The distance between these patches can be used to determine the distance from Flevoland in a northwesterly direction where natural resources should be present in order to fit the mobility radius of EMP hominins.

The EMP artefacts recorded in the ice-pushed ridges in the central Netherlands have a probable age range of 220-170 ka (Van den Biggelaar *et al.*, 2016a), corresponding to MIS 7 and early MIS 6. Although no other evidence of EMP hominins dating to MIS 6 are known (north)west of the central Netherlands (Figure 2. For references see Appendix 1), this may reflect investigation bias and lack of recent research owing to the inaccessibility of these marine and deep subsurface areas. Within the southern North Sea area *in situ* archaeological remains have been found 11 km offshore of southeast England in the lower reaches of the palaeo-Yare fluvial system (Area 240; figure 2) (Tizzard *et al.*, 2014). The sediments in which these artefacts were found were likely to have been deposited within the shallow channels of a braidplain (Tizzard *et al.,* 2014), which is a similar environmental context as the EMP finds from the central Netherlands (see Busschers *et al.*, 2008). Although these artefacts described by Tizzard *et al.*, 2014) probably date to ~250-200 ka BP (MIS 8/7) future research is needed to determine whether within the southern North Sea area archaeological sites dating to MIS 6 are present. The presence of *in situ* archaeological remains in the area of the palaeo-Yare indicates the potential for (geo)archaeological research into EMP hominin activities. Furthermore, the good preservation of the submerged coarse-grained sediments in the cores of Area 240 (Tizzard *et al.*, 2014), allows gravel data from the artefact-bearing interval (unit 3B) to possibly be compared to determine the trend in downstream fining. This comparison may indicate the maximum downstream area within the lower reaches of the palaeo-Yare fluvial system where aggregate can be found that is coarse enough to produce artefacts. Just as for the area northwest of Flevoland, further downstream in the palaeo-Yare, in the region where rocks are not coarse enough for the production of artefacts, EMP hominins could still have undertaken activities by bringing with them rocks to be made into artefacts or ones pre-manufactured as tools.

East of the central Netherlands towards northern Germany, no EMP archaeological sites dating to MIS 6 have yet been found. As most parts of northern Europe were devoid of hominins during cold climatic conditions, like

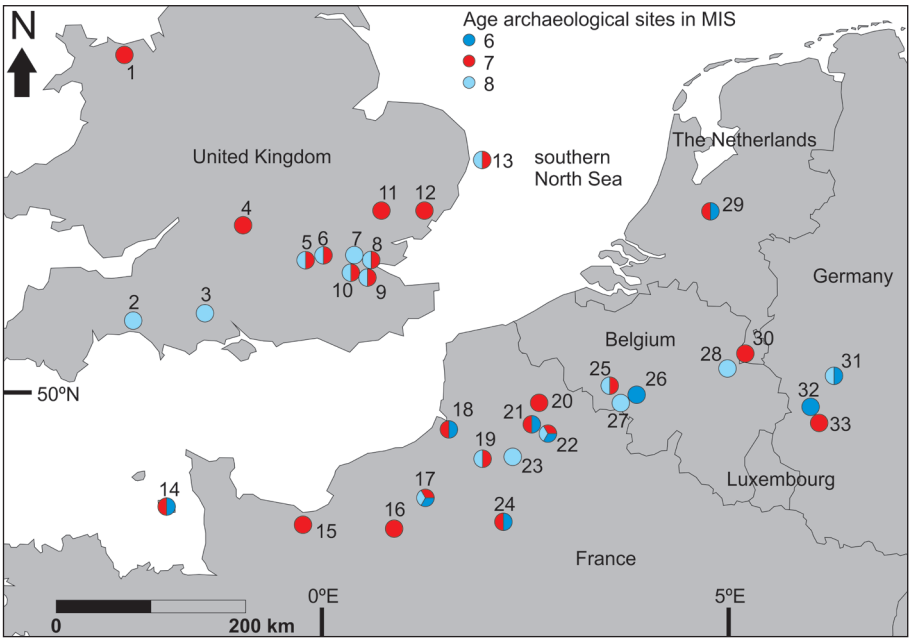


*Figure 2. Overview of most likely age of early Middle Palaeolithic (MIS 8-6) archaeological sites in northwestern Europe. The locations of the archaeological sites are compiled from De Heinzelin and Haesaerts (1983), Buckingham et al. (1996), Conard and Prindiville (2000), Lamotte (2001), Scott and Ashton (2011), Van Baelen and Ryssaert (2011) and Tizzard et al. (2014). Data on the age is compiled for previous research (see Appendix 1 for references). Numbers refer to sites mentioned in Appendix 1 and are used for this research: (1) Pontnewydd; (2) Broom; (3) Harnham; (4) Dix's Pit, Stanton Harcourt; (5) West London (Yiewsley area); (6) Creffield Road; (7) Botany Pit, Purfleet; (8) Lion Pit Tramway Cutting, Thurrock; (9) Baker's Hole and the Ebbsfleet Channel; (10) Stoneham's Pit, Crayford; (11) Jordan's Pit, Brundon; (12) Stoke Bone Bed, Ipswich; (13) Area 240; (14) La Cotte de St. Brelade; (15) Ranville; (16) Tourville-la-Rivière; (17) Le Pucheuil; (18) Saint-Valéry-sur-Somme; (19) Salouel; (20) Biache – Saint – Vaast; (21) Oisiers à Bapaume; (22) Gentelles; (23) Gouzeaucourt; (24) Therdonne; (25) Rissori; (26) Carrière Hélin; (27) Mesvin IV; (28) Kesselt-Op de Schans; (29) Central Netherlands; (30) Maastricht-Belvédère; (31) Ariendorf 1 & 2; (32) Tönchesberg; (33) Schweinskopf-Karmelenberg.*

MIS 6 (Hublin & Roebroeks, 2009), it is unlikely that during these conditions hominins were present east of the central Netherlands (*e.g.* northern Germany). Similarly, in the northern Netherlands, the environmental setting during MIS 6 was probably characterised by a polar desert (Zagwijn, 1973), bordered in the north by the Fennoscandian ice sheet (Busschers *et al.*, 2008), inhibiting hominin activity at that time.

## Younger Dryas (12.9-11.7 ka, late final Palaeolithic)

During the Younger Dryas (YD) (12.9-11.7 ka; Steffensen *et al.*, 2008), sea level in the North Sea was approximately 50m lower than the present-day (see Bradley *et al.*, 2011), resulting in large parts of the North Sea area constituting dry land. At that time, cool climatic conditions prevailed in the Netherlands, combined

with a vegetation type dominated by forest tundra (Hoek, 1997). During this period, the landscape was characterised by elevated aeolian (sand) dunes and ridges within the fluvial systems in southern Flevoland (Eem valley) and northern Flevoland (IJssel-Vecht valley) (*e.g.*, Wiggers, 1955; Menke *et al.*, 1998; Peeters, 2007; Van den Biggelaar *et al.*, in press;). No traces of hominin activities dating to the YD have so far been found in Flevoland. This absence of evidence most likely reflects the thick Holocene cover (up to ~8 m) overlying the YD landscape (i.e. Pleistocene land surface) (Van den Biggelaar *et al.*, 2016), making it difficult to locate YD archaeological remains. Across the rest of the Netherlands a similar situation occurs, with YD archaeological remains primarily recorded in areas that lack Holocene deposits (Van den Biggelaar *et al.*, 2016b). Although the model presented by Van den Biggelaar *et al.* (2016b) to predict the location of YD archaeological remains in southern Flevoland still needs to be tested, it provides a way to investigate other areas where YD archaeological remains have not yet been found (i.e. the western Netherlands and the North Sea area). To test this model two steps must be undertaken. Firstly, to determine the accuracy of the landscape classification generated by the concept of Topographic Position Index (TPI; Guisan *et al.*, 1999; Weiss, 2001), a coring campaign should be undertaken within southern Flevoland in an area that according to this classification has an elevated Pleistocene surface within the zone of highest probability of YD archaeological remains (see figure 5 in Van den Biggelaar *et al.*, 2016b). Based on economic and technological reasons, an elevated area should be selected in the south-eastern part of southern Flevoland where the Pleistocene surface is closest to the present-day ground surface (i.e. thinnest sequence of Holocene deposits; figure 5 in Van den Biggelaar and Kluiving, 2015). If such a coring campaign does not confirm the presence of an elevated Pleistocene surface at that location, the TPI-generated landscape classification should be adapted. However, if the coring data confirms the presence of an elevated area, then the second stage should involve trial trenching of the area to determine the presence or absence of YD remains. This procedure should be performed at several locations to improve the statistical significance of the outcome of the procedure.

Filling in the geographical gap in the distribution of YD archaeological remains in northwest Europe (see Van den Biggelaar *et al.*, 2016b), will be of major importance to advance hypotheses on the YD subsistence economy, settlement patterns and spatial organisation; currently, it is unknown what activities were performed during this period in the western Netherlands and the North Sea area. In particular, the latter area is of major importance because during the YD this location is the lowland part of the landscape and has a high potential for well-preserved archaeological remains on the seabed capable of providing high resolution research data (*e.g.*, Weerts *et al.*, 2012; Peeters & Momber, 2014).

## Mid-Holocene (6000-5400 BP, Early Neolithic)

During the mid-Holocene (6000-5400 BP), the landscape of Flevoland was characterised by a wetland area with localized dryer ridges underlain by glacial tills and aeolian dunes (see Ente, 1971, 1976; Ente *et al.*, 1986; Hacquebord,

1976; Menke *et al.,* 1998; Peeters, 2007; Van den Biggelaar *et al.*, 2015). During this period habitation concentrated on the dryer glacial ridges and aeolian dunes within the wetland region that gradually expanded and transformed from a freshwater tidal area to a peat marshland (Van den Biggelaar *et al.*, 2015). Although archaeological remains that date within the range of 6000-5400 BP have primarily been found on higher ground within the Eem and IJssel-Vecht valleys, this is most likely because until now (geo)archaeological research in the area has focused on those elevated zones. Therefore, it is possible that the known mid-Holocene archaeological remains in Flevoland do not provide a representative overview of the archaeological record as such remains could also be present in the lower-lying zones within the valleys (*e.g.*, the peat areas). Although many of the lower-lying areas within the Eem and IJssel-Vecht valleys were inundated during the mid-Holocene around 6000 BP, large parts of these areas remained dry (see Van den Biggelaar *et al.,* 2015). Future research needs to be focused on these dry areas to determine whether traces of mid-Holocene activity is present.

Within the IJssel-Vecht fluvial system, various levees have been documented that date to the mid-Holocene (*e.g.*, Swifterbant area: Hacquebord, 1974, 1976), however, for the Eem fluvial system, very few levees are documented (see Woltinge, 2010 for an example of a levee in the Eem system). Like the levees in the IJssel-Vecht valley, the levees in the Eem have a high potential to preserve traces of crop cultivation, because of the high natural fertility. To determine the presence or absence of later prehistoric crop cultivation in the levee deposits of the Eem valley a two-step approach is needed. Firstly, the mid-Holocene levees of the Eem fluvial system should be mapped by a combination of coring campaigns and analysis of the surface elevation map of the area (AHN-3: www.ahn.nl). Secondly, the presence or absence of mid-Holocene archaeological remains should be determined on the mapped levees via a coring campaign. If no remains are found during coring, trial trenches should be opened to increase the investigated surface area and thereby also the chance of finding mid-Holocene archaeological remains. For any trench survey, levees should be selected that are closest to the current ground surface to limit financial costs and technical issues. When coring and/or trenching surveys indicate the presence of mid-Holocene archaeological remains on levees in the Eem valley, the sediments in which these remains are incorporated should be sampled for palaeobotanical analyses. It is expected that integrated palaeogeographical mapping and palaeobotanical sampling would yield significant results since archaeological and pollen remains are likely to be well-preserved in the clayey deposits of the levees. These remains are of major importance to improving our understanding of wetland cultivation practices.

## Late Holocene (1200-8 BP, Medieval period and Modern history)

Around 1200 BP the peatland at Schokland (southern Noordoostpolder, northern Flevoland) was inundated and gradually transformed via a brackish environment (~900 BP), into an island in a fully marine environment (~400 BP) (see Van den Biggelaar *et al.*, 2014); today, it forms a landlocked island (created around 8 BP)

(*e.g.*, Van der Heide & Wiggers, 1954). Reclamation of this peatland started possibly as early as 1150 BP (Hogestijn *et al.*, 1994). Due to this reclamation, the surface area of Schokland lowered, resulting in the increasing influence of the North Sea on the former island. As a response to this influence, embankments were constructed in the area since ~750 BP (Van der Heide & Wiggers, 1954; Hogestijn *et al.*, 1994). Until the evacuation of the former island in AD 1859 (Handelingen Staten-Generaal, 1857-1858, 1858-1859 in Geurts, 1991), the inhabitants of Schokland struggled against the impact of the Zuiderzee. Between 1200 and 8 BP clay was deposited on this island, which is located in the former Zuiderzee area (inlet of the North Sea in the centre of the Netherlands). The spatial thickness and distribution of this clay on Schokland is explained by a combination of the location of its embankments and proximity to the coastline (Van den Biggelaar *et al.*, 2014). However, Van den Biggelaar *et al.* (2014) indicated that both the North Sea and the River IJssel may also have affected the Late Holocene sedimentation pattern on the former island as they could have influenced the availability of sediment and the hydrological conditions in the Zuiderzee area at that time. The Late Holocene clay at Schokland contains calcareous foraminifera (*e.g.*, *Ammonia beccarii*, *Haynesina* sp. and *Elphidium* sp.) (Van den Biggelaar *et al.*, 2014), implying marginal marine conditions (Murray, 2006). The presence of these foraminifera indicates that the North Sea was possibly a source area for the Late Holocene clay on the former island. The River IJssel may also have contributed to clay deposition on Schokland during the Late Holocene as the delta of this river is located just east of the former island, indicated by the contemporary surface topography that gradually increases from the eastern side of Schokland to the east (Van Balen, 2008). However, to determine whether the IJssel fluvial system was a source for the Late Holocene clay at Schokland, sediment samples from the river are needed for geochemical (*e.g.* major element composition) and grain size analyses in combination with end-member modelling (un-mixing of grain-size distributions: Weltje, 1997; Weltje & Prins, 2003). Apart from exterior influences on the sedimentation pattern of Schokland, local compaction effects on the clay and peat could also have affected the Late Holocene sedimentation patterns of the clay (Van den Biggelaar *et al.*, 2014). Before the effect of compaction on deposition can be determined, the amount of compaction needs to be studied first. Although the surface downwarping rate at Schokland was investigated by Van den Biggelaar and Pieters (2012), this study focused only on the last 200 years, as surface elevation measurements of the former island are limited to this period. Further research is needed to determine whether this period may be extended by correlating the sedimentary remains of storm surges on Schokland with historical storm records that mention the elevations these surges reached. As the remains of storm surges within the subsurface deposits of the former island have been dated by OSL to ~ AD 1615 and between ~ AD 1745 ± 30 and AD 1785 ± 20) (Van den Biggelaar *et al.*, in prep.), historical sources need to be investigated to determine whether storm events during these periods affected Schokland.

The Zuiderzee already existed prior to AD 1615 (see Vos & De Vries, 2013), indicating that sedimentary remains of storm surges prior to AD 1615 may be present on Schokland. The lack of preservation of such remains could possibly be

related to its distal position to the coastline and the high surface elevation of the central north part of Schokland compared to the remainder of the former island (compare figures 2B and 5 in Van den Biggelaar *et al.*, 2014). To determine the influence of both elevation and distance to the coastline on the deposition of the sandy laminae that are indicative of storm surges, such laminae at the lower more proximate parts of Schokland need to be dated by OSL. If these laminae yield similar OSL dates to the ones at core location 38, further research is required to determine what may have influenced the lack of preservation of sedimentary remains of storm surges at Schokland prior to 1600 AD.

## Conclusions

In this paper we have illustrated the subsurface landscape of Flevoland as recorded in the stack of sedimentary deposits and demonstrated how different landscapes have the potential to record traces of hominin activity that could date back to the period 220-170 ka (MIS 7/early MIS 6). Flevoland was possibly part of the area that was inhabited by the early Middle Palaeolithic hominins of the central Netherlands prior to the Late Saalian glaciation (~150 ka ). This region may have played an important role in the mobility pattern of EMP hominins in the North Sea basin as at that time it was possibly the most northwesternly region with rocks coarse enough to allow the manufacture of artefacts in the region that encompasses the western Netherlands and adjacent offshore area. In the western part of the southern North Sea (offshore of southeast England), the furthest downstream area where such lithics have yet been found, the archaeological potential is currently unknown. However, due to the presence of well-preserved Late Saalian sediments in the southern North Sea area, there is a high potential to determine the trend in downstream fining of these sediments by gravel analysis. These well-preserved sediments, combined with the presence of known *in situ* EMP archaeological remains in the southern North Sea, indicate the potential of the area for (geo) archaeological research into EMP hominin activity. Although such traces dating to MIS 6 are unknown northwest of the central Netherlands, research in the southern North Sea area is needed to determine whether archaeological remains dating to MIS 6 are present in the area.

Well-dated *in situ* YD archaeological remains have not yet been found in Flevoland, possibly due to the thick Holocene superficial sediment cover. The accuracy of the TPI-generated landscape classification for the YD landscape of Flevoland needs to be tested to determine whether it can be used for predictive modelling purposes of YD archaeological remains in buried landscapes (*e.g.* in the western Netherlands and the North Sea). If this classification is accurate, field validation checks are needed to determine whether YD archaeological remains are present within the zone that has the highest probability to contain such material.

During the period 6000-5400 BP, the Eem and IJssel-Vecht valleys transformed from a freshwater tidal area to a peat marshland. While within this area mid-Holocene archaeological remains are only known from the elevated parts of the landscape, future research is needed to determine whether such remains are also present in the lower-lying areas when these were still dry (*e.g.*, around 6000 BP).

Further research is also needed to locate mid-Holocene levees in the Eem valley and determine whether evidence of crop cultivation is present at those levees. Such traces may improve our understanding of wetland cultivation practices.

Between 1200 and 400 BP Schokland gradually transformed from a peatland into a fully marine environment. Although the sedimentation pattern of the Late Holocene clay that was deposited on the former island during the period 1200-8 BP was explained by a combination of embankments and its proximity to the coastline, future research is needed to determine whether the North Sea, the IJssel river and local compaction effects also contributed to the observed pattern. The period for which the amount of compaction can be determined may be extended beyond the last 200 years with the use of storm surge records.

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## Endnotes

a This paper is the first part of the General Discussion chapter in the dissertation of Van den Biggelaar (2017).

## Appendix 1

Most likely age of early Middle Palaeolithic sites in northwest Europe. Location of the sites was compiled from De Heinzelin and Haesaerts (1983), Buckingham *et al.* (1996), Conard and Prindiville (2000), Lamotte (2001), Scott and Ashton (2011), Van Baelen and Ryssaert (2011) and Tizzard *et al.* (2014).

| Site no. (see Fig. 2) | Archaeological site (1) | Most likely age (MIS) (2) | Age in ka (3) | Type of dating (2 and 3) | References |
|---|---|---|---|---|---|
| **United Kingdom** | | | | | |
| 1 | Pontnewydd | late 7 | 200 ± 25 (TL) | Chrono- and biostratigraphy and TL | Green, 1984, 1988 (1), Aldhouse-Green, 1995; Schreve, 1997 (2), Huxtable, 1984 (3) |
| 2 | Broom | late 9/ early 8 | 324-282 | OSL, sedimentary and chronostratigraphy | Salter, 1898; Green, 1988; Marshall, 2001 (1), Hosfield and Chambers, 2009 (2), Toms *et al.*, 2005 (3) |
| 3 | Harnham | late 8 | 265-250 | Amino acid racemization and biostratigraphy | Melville and Freshney, 1982; Bates *et al.*, 2014 (1), Bates *et al.*, 2014 (2-3) |
| 4 | Dix's Pit, Stanton Harcourt | 7 | | Biostratigraphy | Buckingham *et al.,* 1996; Buckingham, 2007 (1), Schreve, 1997 (2) |
| 5 | West London (Yiewsley area) | late 8/ 7 | | Chronostratigraphy | Brown, 1895a, b (1), Ashton *et al.*, 2003; Scott *et al.*, 2011 (2) |
| 6 | Creffield Road | late 8/ 7 | | Chronostratigraphy | Brown, 1886 (1), Ashton *et al.*, 2003; Scott *et al.*, 2011 (2) |
| 7 | Botany Pit, Purfleet | 8 | | Chrono- and biostratigraphy | Wymer, 1968, 1985; Schreve *et al.*, 2002 (1), Bridgland, 1994; Schreve *et al.*, 2002; Bates *et al.*, 2014 (2) |
| 8 | Lion Pit Tramway Cutting, Thurrock | 8/ 7 | | Chrono- and biostratigraphy and amino acid racemization | Dibley and Kennard, 1916; Warren, 1923a, b; Bridgland, 1985; Bridgland and Harding, 1995 (1), Bridgland, 1994; Schreve *et al.*, 2006 (2) |
| 9 | Baker's Hole and the Ebbsfleet Channel | late 8/ early 7 | | Chrono- and biostratigraphy | Spurrell, 1883, 1884; Abbott, 1911; Smith, 1911; Wenban-Smith, 1995 (1), Burchell, 1954; Bridgland, 1994; Schreve, 1997; Scott *et al.*, 2010 (2) |
| 10 | Stoneham's Pit, Crayford | late 8/ early 7 | | Chrono- and biostratigraphy and amino acid racemization | Spurrell, 1880a, b; Kennard, 1944 (1), Schreve, 1997; Schreve *et al.*, 2006 (2) |
| 11 | Jordan's Pit, Brundon | late 7 | 230 ± 30 and 174 ± 30 | Uranium-Thorium (U-Th), chrono- and biostratigraphy | Moir and Hopwood, 1939; Wymer, 1985 (1), Schreve, 1997 (2), Szabo and Collins, 1975 (3) |
| 12 | Stoke Bone Bed, Ipswich | late 7 | | Chrono- and biostratigraphy | Layard, 1912, 1920; Wymer, 1985 (1), Schreve, 1997 (2) |
| 13 | Area 240 | late 8/early 7 | 250-200 | Stratigrapy and OSL | Wessex Archaeology, 2011; Tizzard *et al.*, 2014 (1), Wessex Archaeology, 2011; Tizzard *et al.*, 2014 (2-3) |
| **France** | | | | | |
| 14 | La Cotte de St. Brelade | late 7/ early 6 | 238 ± 35 (TL) | TL, biostratigraphy and pedogenesis | Nicolle and Sinel, 1910; Callow and Cornford, 1986; Pope *et al.*, 2012; Scott *et al.*, 2014 (1), Callow, 1986 (2), Huxtable, 1986; Scott, 1986; Van Vliet-Lanoë, 1986 (3) |
| 15 | Ranville | early 7 | 235-205 | Biostratigraphy, U-Th and ESR | Cliquet *et al.*, 2008 (1), Auguste, 2008; Bahain *et al.*, 2008 (2-3) |
| 16 | Tourville-la-Rivière | 7 | 226-183 | ESR and U-series | Verron, 1979; Vallin, 1991; Guilbaud & Carpentier, 1995 (1), Faivre *et al.*, 2014 (2-3) |
| 17 | Le Pucheuil | late 8/ early 7, late 7/ early 6 | | Chronostratigraphy | Ropars *et al.*, 1996 (1-2) |

| Site no. (see Fig. 2) | Archaeological site (1) | Most likely age (MIS) (2) | Age in ka (3) | Type of dating (2 and 3) | References |
|---|---|---|---|---|---|
| 18 | Saint-Valéry-sur-Somme | late 7/ early 6 (?) | | Chronostratigraphy | De Heinzelin and Haesaerts, 1983 (1-2) |
| 19 | Salouel | late 8/ early 7 | | Chronostratigraphy | Ameloot-Van der Heijden *et al.*, 1996 (1-2) |
| 20 | Biache – Saint – Vaast | late 7 (here: 200 ka) | 175 ± 13 (TL) and 253 + 53/-37 (ESR) | Thermoluminescence (TL), Electron Spin Resonance (ESR) and biostratigraphy | Tuffreau and Sommé, 1988 (1), Sommé *et al.*, 1988; A. Tuffreau, pers. comm. from Rots, 2013 (2), Huxtable and Aitken, 1988; Yokoyama, 1989 (3) |
| 21 | Oisiers à Bapaume | late 7/ early 6 | 194 ± 21 | Infrared Stimulated Luminescence (IRSL) | Tuffreau, 1972, 1976; Koehler, 2008 (1), Balescu and Tuffreau, 2004 (2-3) |
| 22 | Gentelles | late 9/ early 8, late 7/ early 6 | 300-250, 180 | Chronostratigraphy | Tuffreau *et al.*, 2001 (1), Tuffreau *et al.*, 2008 (2-3) |
| 23 | Gouzeaucourt | possibly 8 | | Chronostratigraphy | Sommé, 1975; Tuffreau and Bouchet, 1985; Lamotte, 2001; Tuffreau *et al.* 2008 (1); Tuffreau and Bouchet, 1985 (2) |
| 24 | Therdonne | late 7/ early 6 | 178 ± 11 | Chronostratigraphy, TL | Locht *et al.*, 2000; Hérisson, 2007 (1), Locht *et al.*, 2000 (2-3) |
| **Belgium** | | | | | |
| 25 | Rissori | 8-7 | | Chronostratigraphy | Adam and Tuffreau, 1973 (1), Adam, 1991, 2002 (2) |
| 26 | Carrière Hélin | 6 | | Chronostratigraphy | De Heinzelin, 1959; Cubuk, 1975; Michel, 1978; Cahen, 1984 (1), Haesaerts, 1978; Pirson *et al.*, 2009 (2) |
| 27 | Mesvin IV | 8 | 300-250 | Uranium-Thorium (U-Th), chrono- and biostratigraphy and palynology | Cahen *et al.*, 1984; Cahen & Michel, 1986 (1), Haesaerts, 1978; Cahen *et al.*, 1979, 1984; Cahen and Michel, 1986; Van Neer, 1986 (2-3) |
| 28 | Kesselt-Op de Schans | early 8 | 300 | Chronostratigraphy | Van Baelen *et al.*, 2007, 2008 (1), Van Baelen *et al.*, 2007 (2-3) |
| **The Netherlands** | | | | | |
| 29 | Central Netherlands | late 7/ early 6 (here: 220-170) | 168 ± 19 (OSL) | OSL, typochronology and chronostratigraphy | Stapert, 1981, 1987, 1991; Van Balen, 2006; Van Balen *et al.*, 2007 (1), for literature see discussion in chapter 3 (2), Busschers *et al.*, 2008 (3) |
| 30 | Maastricht-Belvédère | 7 | 250 ± 20 (TL), 220 ± 40 (ESR) | Thermoluminescence (TL), Electron Spin Resonance (ESR) and chrono- and biostratigraphy | Van Kolfschoten and Roebroeks, 1985; Roebroeks, 1988 (1), Van Kolfschoten and Roebroeks, 1985; Vandenberghe *et al.*, 1987; Roebroeks, 1988; Van Kolfschoten *et al.*, 1993 (2), Roebroeks, 1988; Huxtable, 1993 (3) |
| **Germany** | | | | | |
| 31 | Ariendorf 1 & 2 | 8 and 6 | >220 (most likely ~ 250) and 190-150 | Chronostratigraphy/ Tephrochronology | Bosinski *et al.* 1983; Turner, 1986, 1997 (1), Van den Bogaard and Schminke, 1990; Turner, 1997; Richter, 2011 (2-3) |
| 32 | Tönchesberg | 6 | between 121 ± 11 and 129 ± 12 (TL) | TL and chrono- and biostratigraphy | Conard, 1988; Conard, 1992 (1), Conard, 1992 (2), Zöller *et al.* 1991 (3) |
| 33 | Schweinskopf-Karmelenberg | 7 | 198 | U-Th and chronostratigraphy | Bosinski *et al.*, 1986; Schäfer, 1990 (1), Schäfer, 1990 (2), pers. comm. from C. Tiemei in Schäfer, 1990 (3) |

# INTERDISCIPLINARITY BETWEEN HUMANITIES AND SCIENCE

Henk Kars was appointed as first Chair of Archaeometry in The Netherlands in 1994. From 2002 he was full time professor at the Vrije Universiteit Amsterdam, interim Director of CLUE, and founder and Managing Director of the Institute for Geo- and Bioarchaeology. This festschrift volume incorporates original publications in the field straddling the Sciences and Humanities produced by various former PhD-students, post-docs and colleagues.

Landscape archaeology is described in the first cultural landscapes of Europe as a mysterious outcome, while the historical record of surface water flow of the central Netherlands is reviewed. The south-western Netherlands are historically analysed since military inundations during the Eighty Year's War. The palaeolandscapes of the eastern Netherlands are reconstructed to locate the origins of the river Linge. The long time scale is considered in a 220.000 year overview of landscape development and habitation history in Flevoland.

Bioarchaeology is represented in a review of the current state of isotope research in The Netherlands and a correlation between bio- and geochemistry meets an analysis of organic residues in copper corrosion products. Archaeometry reveals the colour of Dutch archaeological textures. The relevance of a quartzite Neolithic axe found near to Huizen, The Netherlands is described.

*CLUES is an international scientific series covering research in the field of culture, history and heritage which have been written by, or were performed under the supervision of members of the research institute CLUE+.*

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